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Lessons Learned from a Front-End Analysis Effort: The Case of Pedestal-Mounted Stinger (PMS)

John E. Stewart

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A front-end analysis (FEA) technique called MIST (Man-Integrated Systems Technology) was used to estimate maintenance manpower and personnel requirements for the Pedestal-Mounted Stinger (PMS) air defense system. The emphasis of this report is on the lessons learned by the MIST team from this effort, including pitfalls of which all FEA practitioners should be aware, and potential solutions to these problems.

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Lessons Learned from a Front-End Analysis Effort: The Case of Pedestal-Mounted Stinger (PMS)

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FAAD MANPRINT Support

FOREWORD

The Manned Systems Group of the Army Research Institute for the Behavioral and Social Sciences is concerned with the application of the principles of MANPRINT (Manpower and Personnel Integration) to the acquisition of weapons systems. At the heart of the MANPRINT initiative is early intervention in the life cycle of a system to assure that manpower, personnel, training, human factors engineering, system safety, and health hazards are confronted and successfully dealt with before a prototype system is built.

This report is concerned with a MANPRINT intervention for the Pedestal-Mounted Stinger (PMS) air defense system. It discusses the use of a front-end analysis (FEA) technique called MIST (Man-Integrated Systems Technology) that provided manpower and personnel estimates for PMS. Despite the inability to gain access to the most desirable types of data, the estimates pinpointed a serious maintenance manpower shortfall at organizational level.

The emphasis of ~~the~~ this report is on the lessons learned in attempting to apply MIST to PMS, some pitfalls of which all FEA practitioners should be aware, and potential solutions that could facilitate FEA applications in future acquisitions. (KR)

Findings were presented at the 32nd Annual Meeting of the Human Factors Society at Anaheim, California, in October 1988. The Directorate of Combat Developments and the Air Defense Board at Fort Bliss, Texas, were also periodically briefed on the results of the effort. As a consequence of the PMS MIST project, the Army was able to revise its maintenance manpower requirements for the system.

EDGAR M. JOHNSON
Technical Director

LESSONS LEARNED FROM A FRONT-END ANALYSIS EFFORT:
THE CASE OF PEDESTAL-MOUNTED STINGER (PMS)

EXECUTIVE SUMMARY

Requirement:

To demonstrate that an automated front-end analysis (FEA) technique using a notional baseline comparison system (BCS) can be applied to produce useful manpower and personnel requirements estimates for a new system during Non-Development Item Candidate Evaluation (NDICE).

Procedure:

MIST (Man-Integrated Systems Technology) was employed in order to generate manpower and personnel estimates for the Pedestal-Mounted Stinger (PMS) component of the Forward Area Air Defense system. Because detailed descriptions of the two candidate systems were not available, a comparative model of each candidate could not be developed. A BCS was configured. This was a generic model and not a precise representation of any proposed system.

Findings:

Although the usefulness of MIST as an FEA technique was demonstrated, problems were encountered. The most serious problem was the lack of access to the contractors' proposals. However, the generic BCS was sufficient to pinpoint maintenance manpower problems in the PMS organization. Although MIST is much less time consuming and labor intensive than HARDMAN (hardware vs. manpower), increased user-friendliness could encourage use among combat and materiel developers.

Utilization of Findings:

The lessons learned from PMS MIST demonstrate that, even when there is a disparity between the data base requirements for MIST and the actual data available to the FEA practitioner, a less rigorous set of data assumptions and a generic BCS should provide meaningful manpower and personnel estimates for the candidate selection process.

LESSONS LEARNED FROM A FRONT-END ANALYSIS EFFORT: THE CASE OF PEDESTAL-MOUNTED STINGER (PMS)

CONTENTS

LESSONS LEARNED FROM A FRONT-END ANALYSIS EFFORT: THE CASE OF PEDESTAL-MOUNTED STINGER (PMS)

INTRODUCTION

Overview

The operation and repair of complex military systems such as PMS can impose severe workload demands, especially for maintainers. Many of these systems are intricate and the aptitudes required to monitor, operate, and maintain them are spread quite thinly in the general population. Maintainers for these systems, especially electronic ones, are hard to recruit and even harder to retain. Training is long and will continue to get longer as more complex systems are introduced into service.

Kerwin et al. (1980) voiced these concerns in a report on the growing crisis brought on by this mismatch between human resources and technology. The authors recommended that manpower, personnel, and training (MPT) concerns be integrated into the requirements and acquisition documents that track the Life Cycle Systems Management Model (LCSMM). They further stated that the LCSMM has not been sufficiently sensitive to MPT demands, especially when expediency dictates accelerated acquisition.

If one also considers the fact that the availability to the Army of high-aptitude recruits is not increasing, then the reason for the MANPRINT (Manpower and Personnel Integration) initiative becomes quite clear. In concise terms, MANPRINT refers to the whole process of optimizing the relationship between hardware and human performance capabilities and limitations. It directs attention to the domains of manpower, personnel, training, human factors engineering, health hazards, and system safety as early in the life cycle of a new system as possible. Central to MANPRINT is the assumption that human performance is an integral part of total system performance. Battlefield effectiveness depends just as much on the ability of the soldier as it does on the capabilities of the system itself.

Front-End Analysis (FEA)

One of the most critical aspects of the entire MANPRINT process is FEA, which consists of a family of methods designed to generate manpower, personnel, and training (MPT) estimates for an emerging system long before it is built or fielded. Comparisons can be made between the proposed system, similar predecessor systems, and system concepts with the intent of discovering and identifying tasks, pieces of hardware, or training courses that make excessive demands on MPT resources ("high drivers"). These are most easily dealt with early in the life cycle of a system, when their impact can be minimized.

HARDMAN-MIST. HARDMAN (Hardware vs. Manpower) is one of a family of FEA methods used to determine maintenance-related MPT needs. Like other FEA methods it is a useful tool which can aid in the identification, elimination and containment of MPT high drivers. Essential to HARDMAN and its automated derivative, MIST (Man-Integrated Systems Technology) is the establishment of a baseline comparison system (BCS) which consists of components (systems and subsystems) similar to those on the predecessor and proposed systems. The BCS may have no real existence separate from those components. It is an heuristic bridge from the predecessor, which incorporates old and mature technologies, to the proposed system, which may incorporate many new technological approaches. Consequently, some of the components on the BCS may not be currently fielded on any predecessor, or may not exist at all. They may, however, have some direct lineage to currently-existing components. By constructing a notional model in this way, one can get a picture of the maintenance workload requirements for the new system.

MIST Inputs. One example of MIST input is RAM (Reliability-Availability-Maintainability) data on proposed or similar fielded systems. These data normally consist of a list of systems and subsystems down to the lowest level of indenture, the military occupational specialties (MOSs) performing the repairs, the Mean Time to Repair (MTTR) and the Mean Time Between Failures (MTBF) for each component. Also required are data on attrition, promotion and transient rates, and training time for the maintainer MOSs.

Information on usage rates and operational scenarios can be gleaned from the various requirements documents such as the Operational and Organizational (O&O) Plan and the Required Operational Capabilities (ROC) document.

MIST Outputs. Typical outputs include the number of MOSs required at organizational and direct support levels, their pay grades, workload in hours (per 7 days), number of MOSs required in the personnel pipeline to support a battalion (or total buy) of the system at a given point in time, and annual accessions. Training estimates are also produced. These include such variables as total training cost, cost per graduate, per course and per MOS, number of training days, and instructors required.

Background

PMS is one of four new systems that will comprise the Forward Area Air Defense (FAAD) System, replacing the Short Range Air Defense (SHORAD) System. It will be a self-propelled, lightweight, highly-mobile, air transportable platform with primary armament of launch-ready Stinger missiles and a complementary predicted-fire weapon (gun) providing missile dead space coverage and ground defense. PMS is primarily designed to be deployed in the brigade rear area to provide air defense coverage for critical assets.

It will be capable of engaging low altitude high performance aircraft, air attack and standoff helicopters, as well as defending itself against dismounted infantry and lightly armored vehicles. PMS will also provide shoot-on-the-move air and self defense coverage during convoy deployment. Its prime mover will be the High Mobility Multipurpose Wheeled Vehicle (HMMWV) with an 8600 pound Gross Vehicle Weight modification.

The predecessors to PMS are towed Vulcan and the Stinger Man Portable Air Defense System (MANPADS). PMS will be considerably more complex than either predecessor, in that it will be equipped with sophisticated electronic sensors as well as Built-in Test (BIT) equipment for the detection and isolation of electronic failures. A highly similar system, the Lightweight Air Defense System (LADS), had been built and proposed to the Army as an interim system; it was not purchased, however.

The PMS MIST Project

Statement of the problem. The Army Research Institute for the Behavioral and Social Sciences (ARI) became involved in the FAAD acquisition through an agreement with the U.S. Army Air Defense Artillery School (USAADASCH) at Fort Bliss, Texas, in March, 1986. At that time the question of the maintenance burden (workload) on the PMS had not yet been addressed in detail.

The FAAD Table of Organization and Equipment (TOE) was to be constrained by the manpower ceiling imposed for SHORAD, with total spaces not to exceed 626 spaces for a heavy battalion. Adding extra manpower spaces was considered out of the question in view of the imposed ceiling. Whether this ceiling or "footprint" reflected actual maintainer workload was not known.

Some form of FEA such as MIST was needed to provide manpower and personnel estimates that were workload-driven. Only four positions were allocated for the MOS 24X system mechanic, although in the judgment of subject matter experts (SMEs) at Fort Bliss, PMS would be more complex electronically than Towed Vulcan, which required nine MOS 24M system mechanics. The rationale for the small number of 24X spaces for PMS was predicated on the assumption that much of the former's workload would be shifted to the MOS 16X operator-maintainer.

Objectives of the MIST analysis. FEA methodologies like MIST can be employed at various stages of the acquisition process. At the early conceptual phases, only a notional model based on representative predecessors is available. From the BCS, maintainer workload and hence manpower requirements can be generated. At the later phases, after candidate prototypes have been built, MIST can compare these actual systems to generate estimates for each of them, thereby aiding the acquisition decision process. The objective of the current analysis was to provide comparative estimates as input into the Source Selection Evaluation Board's (SSEB's) evaluation of two systems. A second

objective was to determine if the MANPRINT guidance provided by MIST, whether the BCS was notional or system specific, would be useful to key decision makers in the acquisition process. Finally, it was important to know if MIST, unlike its predecessor, HARDMAN, can be performed successfully by a team of only two analysts. HARDMAN normally requires a team of eight or more analysts, mostly engineers.

Scope of the present analysis. Time and data constraints limited the scope of the analysis to manpower and personnel estimates. Training estimates would have also required detailed maintenance task lists, which were not available. Only generic "pull and replace" maintenance task lists were available. In short, the MIST team had only gross, overall requirements data which could only be used to construct a BCS. As will soon become apparent, for reasons beyond the control of the MIST team, no data were available on either of the two proposed systems (Boeing Avenger and LTV Crossbow).

THE MIST ANALYSIS AND ITS FINDINGS

Problems and Solutions

Non-availability of critical data. Probably the most important source of data for MIST is a detailed description of the proposed system, including RAM estimates and MOSs performing maintenance tasks. In order to collect these data, the analysis team must be allowed to examine contractors' proposals, which are kept on file at the Program Manager (PM) Office. These sources of data, however, are often labeled as competition-sensitive. Release to any parties outside of those directly involved in source selection and evaluation is forbidden by law. The determination was made that the ARI team, not being part of the SSEB, had no right of access.

The Directorate of Combat Developments (DCD) likewise was unable to see the proposals, with the exception of one person who was on the SSEB. Both ARI and DCD were attempting to address key issues involving maintenance manpower without knowing each contractor's technical approach. This put the Combat Developer (CD) in the position of having to rely on notional or generic system descriptions, which are most valuable at early conceptual phases of the LCSMM.

The LADS HARDMAN. Fortunately, a HARDMAN analysis had been done on a very similar PMS system, the LADS, which, though never fielded, evolved into PMS for FAAD. The two LADS prototypes, the Boeing Avenger and the LTV Setter, became PMS prototypes, Avenger and Crossbow. Thus it was decided that the hardware commonality would make a MIST analysis possible, provided that data from the FAAD PMS O&O Plan and ROC could be entered into MIST. The operational scenarios and usage rates for PMS and LADS differed considerably. One of the chief hardware differences between LADS

and PMS was that the former was equipped with a sensor suite, which was later deleted, primarily because PMS will use passive sensors.

These data sources (the LADS HARDMAN disc, the O&O Plan, and the ROC) did allow the construction of a notional prototype BCS from which manpower and personnel estimates could be generated. Even though PMS was much further along than this, it seemed that workload-driven maintenance manpower estimates from a generic PMS prototype would still be useful to DCD and to the SSEB. The MIST team was later to learn that the estimates were especially useful to both.

Maintenance Manpower Requirements

A MIST analysis was performed on the BCS using data from the LADS HARDMAN, the ROC and O&O Plan for FAAD PMS. Results showed deficiencies in the area of systems maintenance, with a requirement for 13 24X system mechanics where only four had been designated in the TOE. Workload high drivers, which make disproportionate demands on MPT resources, were the Forward Looking Infrared (FLIR) system, the microprocessor for the Fire Control Computer, the Stinger Missile Pods, and the HMMWV vehicle. The FLIR stood out as a high driver, and is the main reason why more 24Xs will be required than proposed. The HMMWV, while fairly maintenance-intensive, could adequately be supported by only three 63B wheeled vehicle mechanics, far fewer than the ten proposed in the TOE.

Sensitivity Analysis

Sensitivity analysis is a decision aid employed early in the acquisition process, in which the consequences of potential MPT trade-offs are explored. The problem at hand is the large number of 24Xs required to maintain the system. The proposed solution is to reallocate portions of the 24X's workload to the 16X, thereby reducing the number of 24Xs needed. One key variable affecting the workload hand-off was the success or failure of the Built-in Test (BIT) diagnostic system at isolating electronic faults.

The results of the sensitivity analysis showed that the requirement for only four 24Xs in systems maintenance was reasonable so long as BIT functioned optimally (81% successful fault isolation) and the 16X was able to (a) diagnose 100% of the faults with BIT and (b) repair all of those faults diagnosed.

DISCUSSION

What Has Been Learned from PMS MIST

In spite of the pitfalls encountered, the results of PMS MIST had significant impact as useful input into the system acquisition decision process. In fact, a brief synopsis of the findings was attached to the SSEB's PMS Test Report. There were no other maintenance issues addressed in the testing of the two PMS candidates, apart from contractors' collection of RAM data, using their own personnel.

FAAD is a fast-track acquisition program whose goal is to find a replacement for the DIVAD (Division Air Defense) system that was cancelled in 1985. The fact that this acquisition is a "fast-moving train" has made adequate MANPRINT intervention very difficult. PMS is a non-development item (NDI). This allows the acquisition process to be expedited. It may very well be that intensive application of MANPRINT tools to acquisition is just as crucial here as for a developmental system. The speed of the acquisition process makes it very difficult to attack MPT problems effectively. This suggests the need for an FEA tool that can be applied quickly by a small team of analysts. However, there are some obstacles that must be overcome.

One serious problem with RAM data on PMS and other FAAD systems is that many of the failure and repair time estimates are arrived at intuitively or by averaging aggregate data across other systems. Likewise, a good number of SMEs interviewed by the MIST team did not know the origin of many of these estimates. This "rule of thumb" way of deriving RAM figures in spite of the availability of more sophisticated sources of data, like SDC (Sample Data Collection) is an anachronism. The resulting BCS is crude, lacking much of the detail needed for MIST. Even if a BCS is generic or notional, it need not be simplistic and inaccurate.

To date, there are several system performance and maintenance data bases but they are formatted quite differently. Some are centralized and others are not. The most time consuming part of doing HARDMAN or MIST is consolidation of a usable data base. Data still must be entered into MIST manually, a process which is tedious. Data entry which took the MIST team several days to accomplish could have been done in minutes if such capability had existed. It certainly is within the capability of current software technology to develop a data base that loads automatically into MIST. Normally, a full MIST analysis should take two full man years; the present analysis took only one.

The Need for Greater Flexibility in Data Requirements

The data and the BCS comprising the MIST analysis only marginally met the formal requirements for this FEA method. Data of sufficient detail were hard to obtain. Perhaps there is a discrepancy between the formal requirements of MIST and what is

actually available to the analyst. If this is the case, then MIST should be made more flexible in the level of detail of RAM data that it can accept. The PMS MIST analysis suggests its capability across a broad spectrum of data. There is nothing wrong with making do with less than ideal data during the conceptual phase of a weapons system's life cycle, if the "gaps" of missing detail and data can be filled in later. If increased utilization can be attained at the cost of somewhat reduced accuracy, then the trade-off is worthwhile. It would also seem reasonable to adapt MIST to the kind of RAM data that one is most likely to encounter in the conduct of FEA. These data generally lack much of the detail as to level of indenture of systems and subsystems as is traditionally required by MIST. Frequently the RAM Rationale Reports, appended to the ROC documents, merely list major systems, such as the Laser Rangefinder and the FLIR, along with the MTBF and MTTR for the system. Recall that MIST normally requires a much more thorough breakdown than this, down to the subsystems and assemblies, as well as maintenance tasks and the MOSs who will be performing these tasks. If estimates are to be made beyond the BCS, MIST requires RAM data for systems, subsystems and assemblies of fielded systems similar to those of the proposed systems.

Logisticians, branch managers and analysts may not have the time or resources to collect these kinds of data. Finally, it should be mentioned that the absence of a sensitivity analysis routine within MIST was a serious drawback in light of the criticality of BIT as a determinant of maintainer workload. In fact, one of the key contributions of this effort was the application of sensitivity analysis, a methodology that was performed manually because MIST had no provision for it.

Facilitating Access to Documents

It should be possible to avoid recurrences of document access problems in the future, by inserting language in Requests for Proposals (RFPs) and writing MANPRINT regulations requiring that whatever data are deemed necessary and essential for MANPRINT-related analyses be made available to bona fide analysts who are supporting the acquisition. There is some indication that this obstacle may soon be removed. One member of the MIST team has been placed on the access list for the proposals for another component of the FAAD system. Another possibility would be to appoint analysts from ARI who can contribute MPT estimates and other services as consultants to the SSEB, making them privy to such information. Access to detailed RAM data from proposals is most crucial at the later stages of weapons system development, when the SSEB needs to have comparative maintenance workload figures to guide their candidate evaluations.

One recommendation from Kerwin et al. (1980) is especially well-taken. The colocation of the PM and TRADOC Systems Manager (TSM) offices would have facilitated the acquisition decision process for PMS. The large geographical separation of TSM and PM

offices can inhibit effective organization and communication. This was certainly a problem throughout the PMS MIST project; DCD was approximately 1200 miles from the PM office, where most of the RAM data and other technical sources on PMS were kept. The RAM data in DCD's possession were largely from the RAM Rationale annex to the ROC. Many of the estimated repair times were attributed to MICOM (Missile Command) assessments, with no explanation of the methodologies used or their sources. In such a situation regular face-to-face interaction between DCD and their MICOM counterparts would have greatly helped both organizations in their efforts to come to grips with the manpower and personnel issues that were the focus of the MIST effort.

SUMMARY AND CONCLUSIONS

Before requiring that FEA and other analyses be done on a system, data requirements should be clearly stated, and systemic channels, that govern the flow of information between parties involved in the acquisition process, opened. This would be a fundamental first step in moving from a set of policy statements that are collectively referred to as MANPRINT to a genuine program which will attain goals consonant with these statements. In brief, MANPRINT should be applied to the organizational dynamics of the acquisition process as well as to the weapons system itself. The FAAD PMS acquisition, which proceeded more rapidly than most, provided a challenge to anyone involved with MANPRINT; requirements documents were out of synchrony with the cycles of the Accelerated Systems Acquisition Process. For instance, the PMS system existed in the form of the LADS prototypes before the ROC was written. This was largely due to the previous existence of LADS and the requirement that PMS and FAAD consist of NDI items.

The Lesson from Other Systems: Reverse Engineering

The problems that were evident in the conduct of PMS MIST (such as the unclear conception of manpower requirements at a late stage in the acquisition process and the early commitment to BIT as a panacea for maintenance manpower problems) seem similar to earlier ones which preceded the MANPRINT initiative by a few years.

A report by Promisel et al. (1985) which performed reverse engineering analyses on four new weapons systems, pointed to fundamental problems in the MPT areas that could have been averted if confronted at an earlier stage of the acquisition cycle. The brief discussion to follow will concentrate on MPT problems in older systems that appear similar to those that impacted PMS MIST, especially in the area of maintenance manpower requirements.

An historical lesson. In the case of the Multiple-Launch Rocket System (MLRS), cited in Promisel et al. (1985), the lack of a well-developed system description before acquisition resulted in problems in determining who the maintainers would be and how they would be trained. If the system concept had been clearer at the outset, the CD would have had a better foundation for making MPT recommendations long before fielding. One should also note that the acquisition process was accelerated to the point where various requirements documents were out of phase with the development of the system itself. Similarly, in the case of the M1 tank, the lack of a clear understanding of the BIT system, the maintenance tasks and their manpower requirements resulted in severe MPT problems after the tank was fielded. It was uncertain as to whether the MOS who was to perform the maintenance tasks could really perform them.

This, coupled with the poor performance of the BIT equipment, resulted in a training program which the authors describe as "volatile", with Programs of Instruction (POIs) changing constantly.

In a similar vein, the plan to have the MOS 16X perform operator and maintainer tasks on PMS was abandoned in light of uncertainty that BIT would live up to expectations. Initially, it was believed that the BIT system would reduce the need for MOS 24X maintainers. BIT performance has shown considerable variation, and fault isolation in military systems has seldom been better than 50%. Thus a single point estimate may not be as useful to decision makers as a set of manpower estimates over a range of BIT fault isolation rates. Sensitivity analysis of the MIST output showed that if BIT performed in a manner consistent with past experience, a serious manpower shortfall of MOS 24Xs would result at organizational level. Cross-training the 16X as an operator-maintainer under these circumstances would save few 24X spaces and result in much greater expense than simply retaining the 24X in the FAAD TOE.

The Legacy of PMS MIST

Under much less than ideal conditions, an FEA tool like MIST can be used to illustrate manpower-personnel trade-offs which can effectively impact candidate evaluation decisions. The PMS MIST effort has been deemed a MANPRINT success, as evidenced by the fact that the SSEB considered the MIST results important enough for incorporation into their final test report. The fact that MIST was one of the few efforts which actually addressed maintenance problems during the PMS acquisitions process is noteworthy. As a result of PMS MIST, the Combat Developer recommended more maintainers at organizational level, though the total manpower ceiling imposed on the FAAD Heavy Battalion will limit the number of spaces to around eight or nine, fewer than the 13 recommended by MIST on the basis of a generic BCS.

The Line of Sight-Forward (Heavy) MIST analysis. The success of PMS MIST provided the MIST team with an opportunity to apply the methodology to another component of FAAD, the LOS-F(H). This project presented an even greater challenge due to the time frame (three months) which forced a reliance on contractors' estimates and the RAM Rationale instead of the more reliable SDC and Manpower Requirements Criteria (MARC) RAM data. In spite of the much less refined data base and the relatively crude BCS (which seldom went below the system-major subsystem level of indenture), useful maintenance manpower estimates were produced. The analysts made it clear to the SSEB that the LOS-F(H) estimates should be taken as an optimistic, or best case, scenario for the maintenance demands imposed by this system (Stewart & Shvern, 1988).

Although permitted access to the proposals for the four LOS-F(H) candidates, the analysts found that RAM data were either sketchy, inappropriate, or lacking altogether for three of them.

Thus, it appears that access to the proposals in itself does not ensure adequate or accurate RAM data. If the analyst has time, he or she can search various SDC and MARC data bases for systems and subsystems similar to those on the proposed systems and BCS.

Barring this, the analyst has the choice of either accepting contractors' estimates on faith or tempering these with lessons learned from previous analyses and from the insights of SMEs experienced in the maintenance of similar systems. In this way the analyst will develop a "feel" for these estimates, with the consequent ability to make adjustments when necessary.

In conclusion. MIST and other FEA methodologies hold much promise as labor-saving procedures for estimating MPT requirements for new Army systems. These methodologies are rapidly evolving into automated systems which are much more powerful and user-friendly than HARDMAN or even MIST. The PMS analyses did, however, turn up one serious obstacle to their implementation, namely, the relative unavailability of accurate RAM data. Consequently, it appears that, if FEA methods are to live up to their potential, accessible RAM data bases must be developed concurrently with them. Otherwise, the compilation of a consolidated data base will remain the most demanding part of MIST or of any other FEA method requiring such data, no matter how automated or advanced.

REFERENCES

Kerwin, W. T., Blanchard, G.S., Atzinger, E.M. and Topper, P.E. (1980). Man/machine interface: A growing crisis. (Problem Areas Discussion Paper No. 2, AMSAA, August; AD B 071081).

Promisel, D., Hartel, C.R., Kaplan, J.D., Marcus, A. and Whittenburg, J.A. (1985). Reverse engineering: Human factors, manpower, personnel and training in the weapon system acquisition process. (ARI Technical Report 659; AD A 157693).

Stewart, J. E., and Shvern, U. (1988). Application of HARDMAN II methodology to the Army's Forward Area Air Defense (FAAD) system. Proceedings of the Human Factors Society 32nd Annual Meeting, 1117-1121.